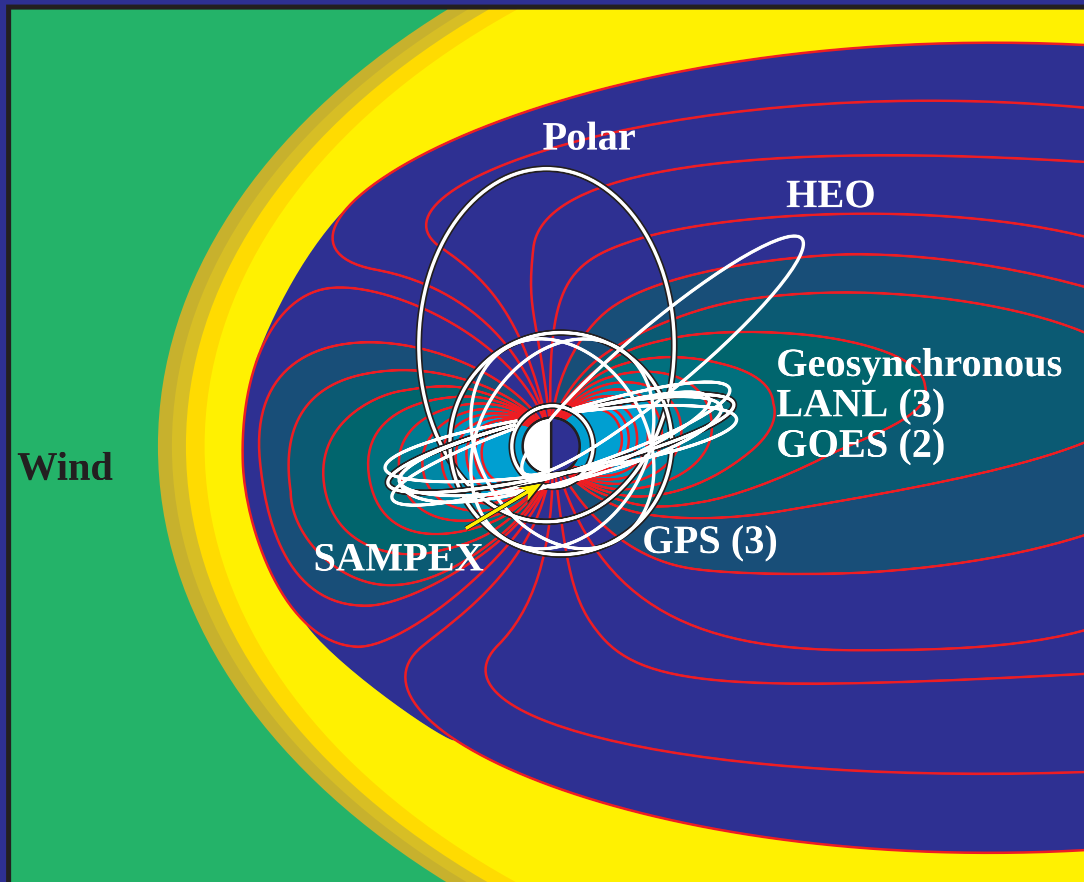
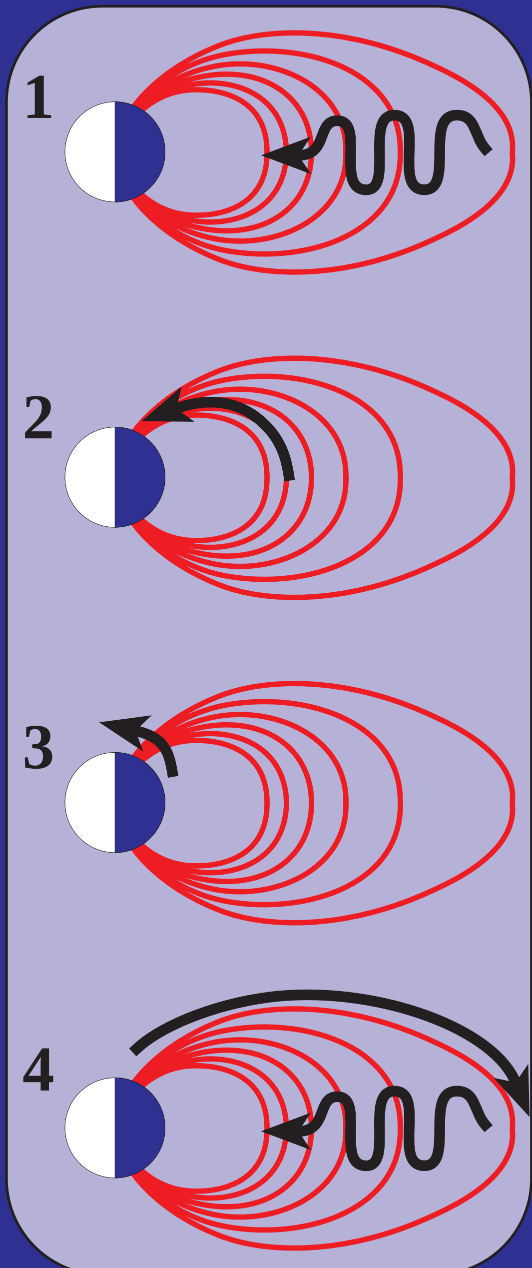
Relativistic Electron Flux Variations
A New, Global, ISTP Perspective



Reeves, Baker, Belian, Blake, Cayton, Fennell, Friedel, Henderson, Kanekal, Li, Meier, Onsager, Selesnick, Spence



The Recirculation Model

Developed to Explain:

- Acceleration to high energy
- Delay of peak at geosynchronous
- Increasing delay with energy

Characteristics:

- Buildup of fluxes is slow (2-6 days)
- Fluxes vary simultaneously at all L
- Source is outside geosynchronous

Problems:

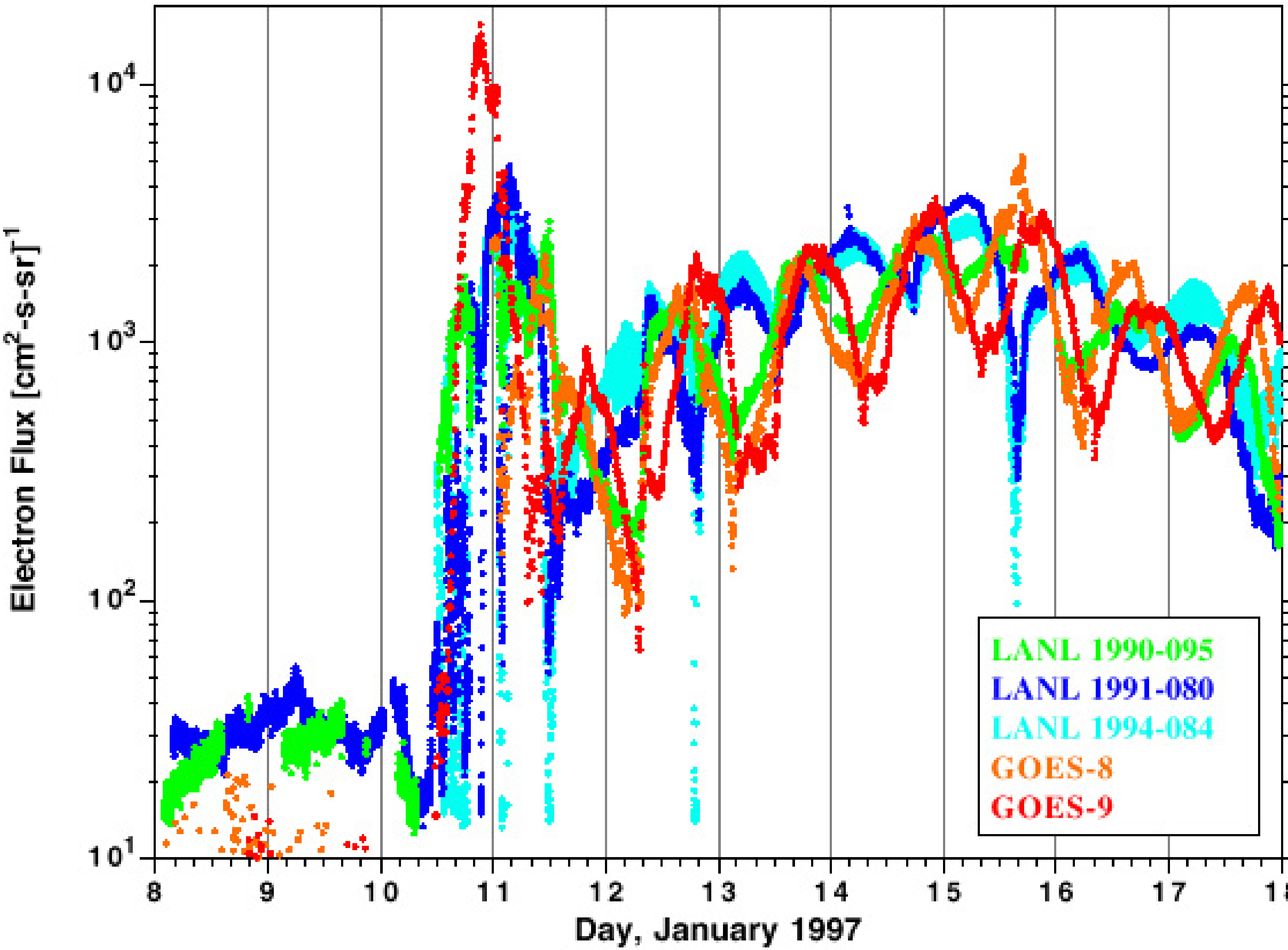
- Unknown processes especially step 3
- Acceleration continues after SW disturbance
- Can’t explain multiple peaks

G. D. Reeves, AGU Fall Meeting, Dec. 1997.

Outline

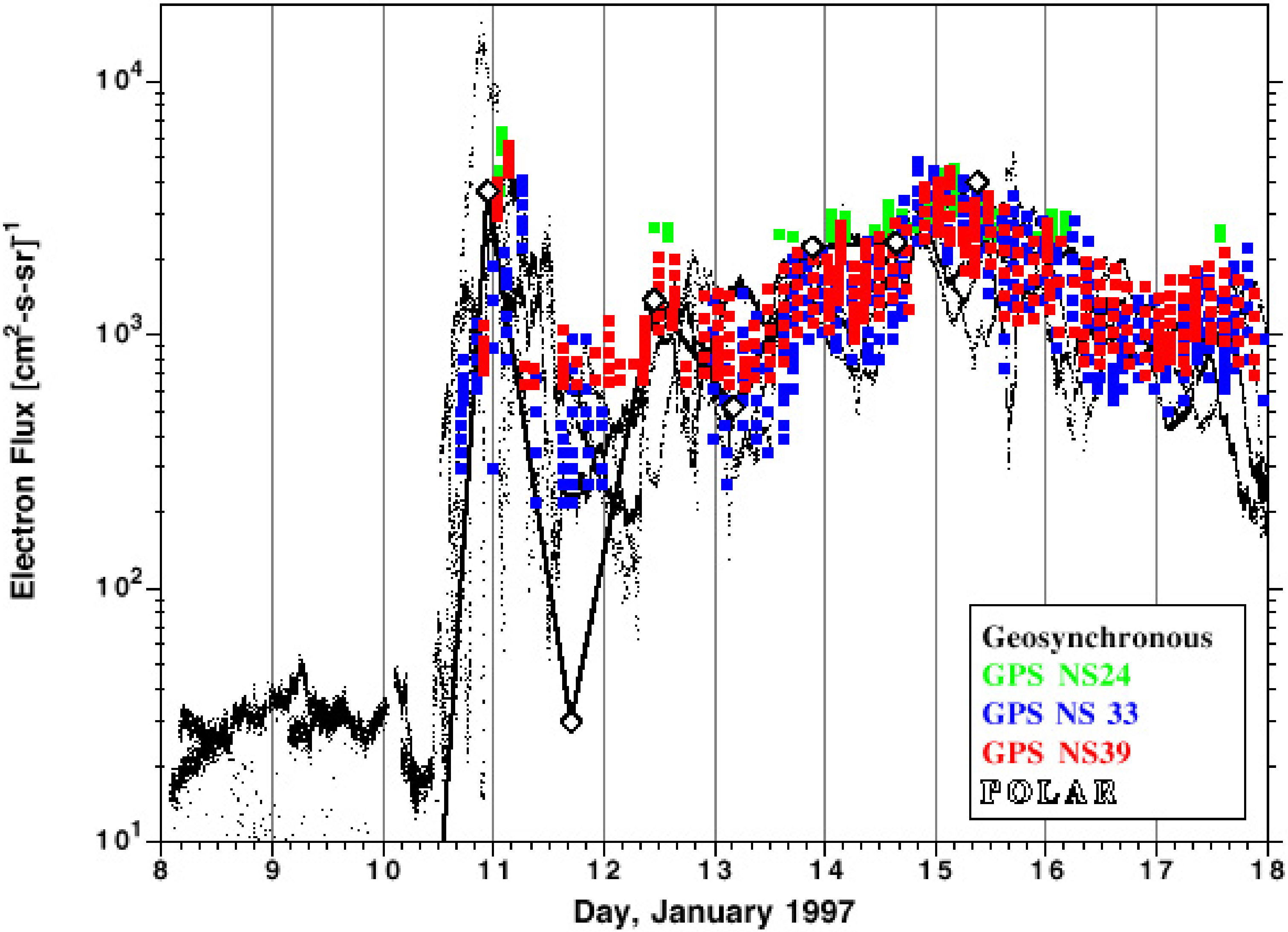
- The January, 1997 magnetic storm included a strong relativistic electron event
- Unusually well-observed by a large number of satellites but otherwise not an unusual event
- >2 MeV electron fluxes at geosynchronous showed two distinct flux peaks
- The fluxes at L≈4.6 behaved quite differently than the fluxes at L≈6.6
- Acceleration of >2 MeV electrons occurred at L≈3.5-5.5 over ≈12 hours
- The two flux peaks appear to be due to particle transport rather than delayed or on-going acceleration
- These observations are not consistent with the recirculation model

Relativistic Electrons – Energies Above ≈2 MeV
Geosynchronous Satellites, L=6.6

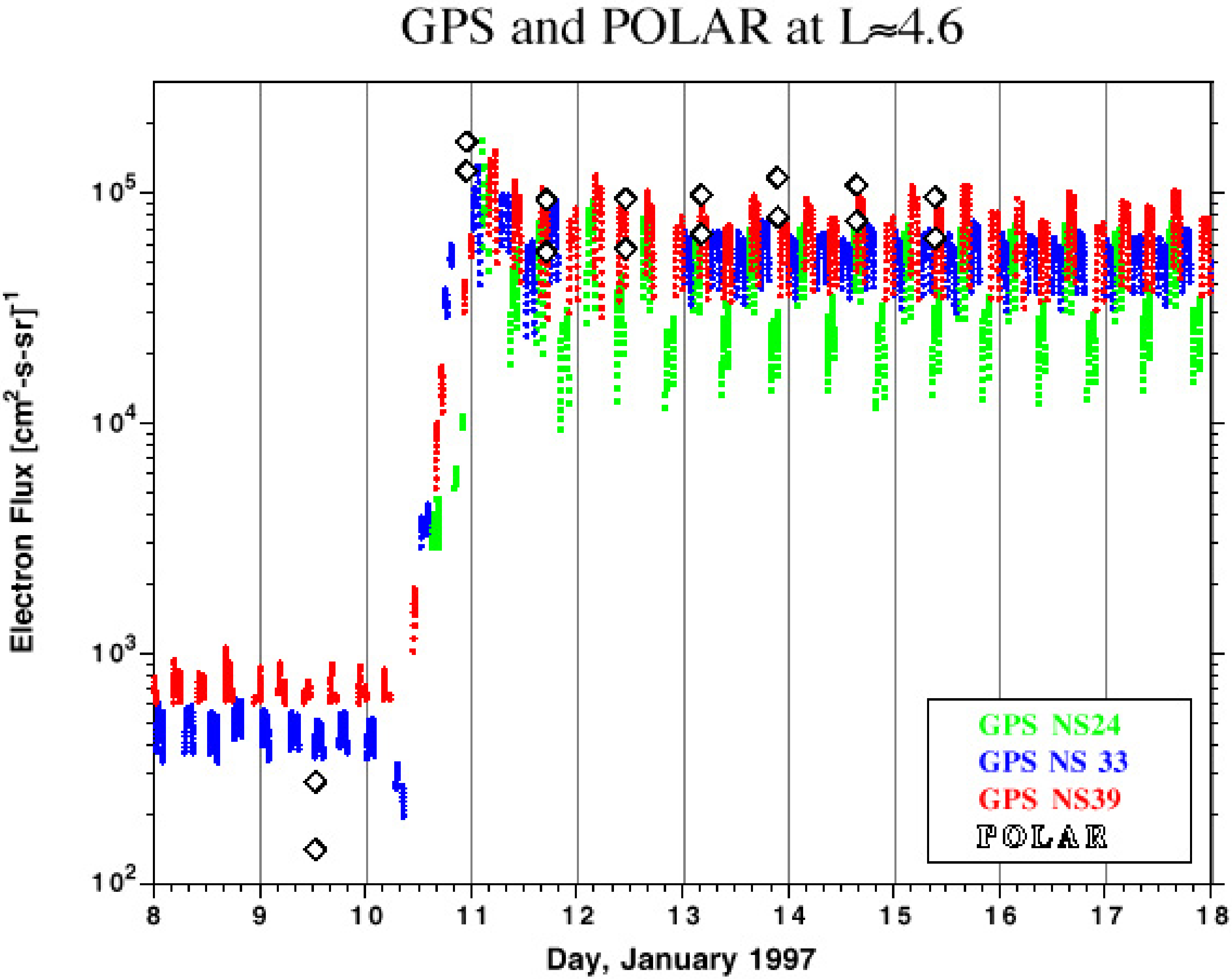


G. D. Reeves, AGU Fall Meeting, Dec. 1997.

GPS and POLAR at L≈6.6

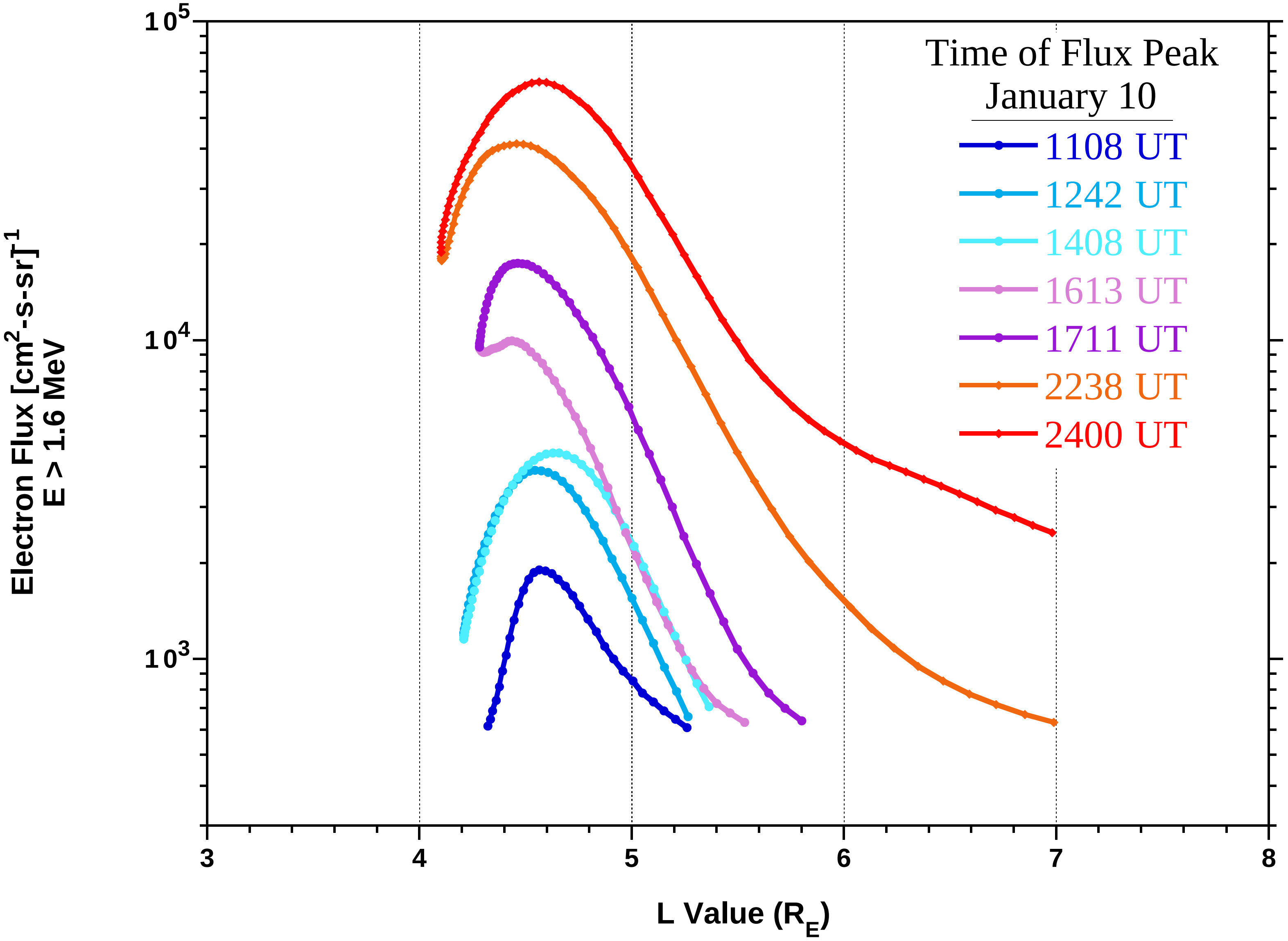


G. D. Reeves, AGU Fall Meeting, Dec. 1997.



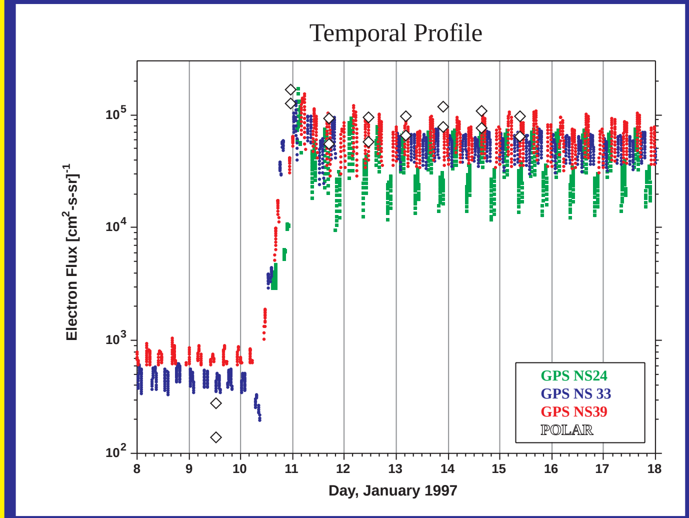
G. D. Reeves, AGU Fall Meeting, Dec. 1997.

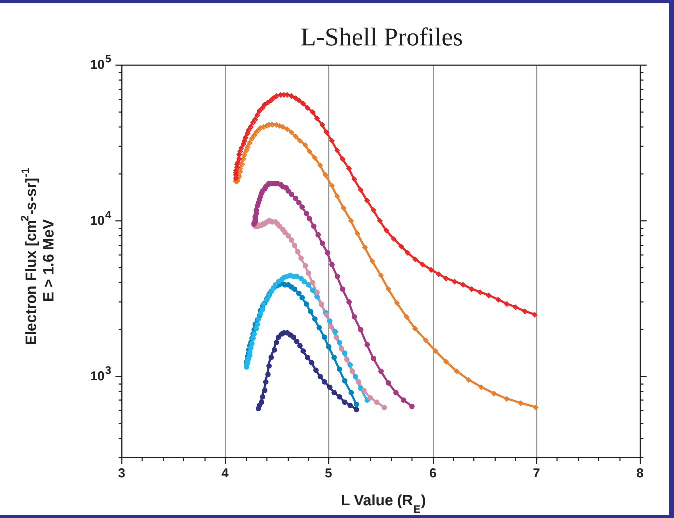
GPS L-Shell Profiles



G. D. Reeves, AGU Fall Meeting, Dec. 1997.

Acceleration Phase

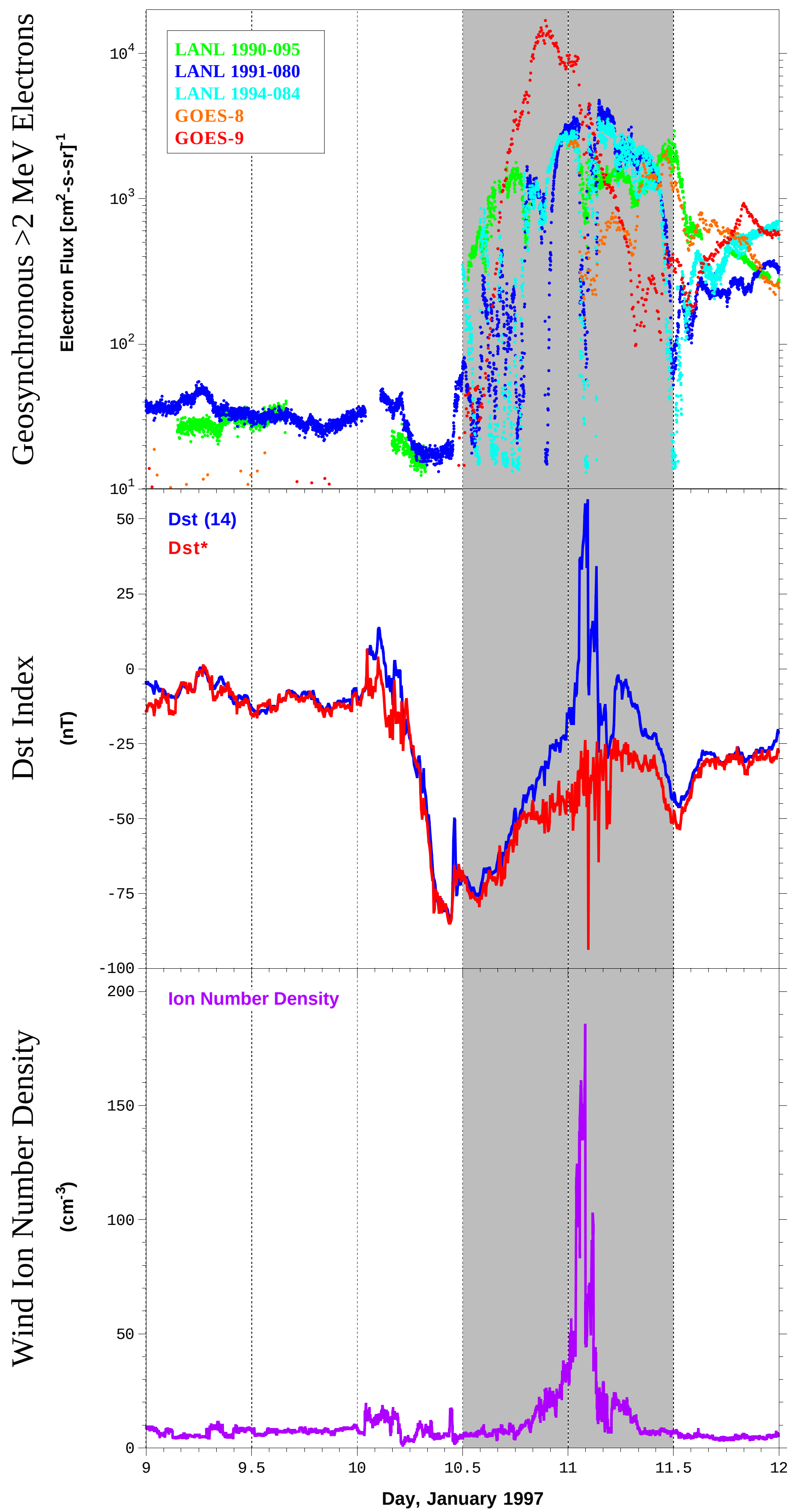




- Fluxes of >2 MeV electrons increase simultaneously over L≈3.5-5.5
- Therefore the source is probably ***inside*** geosynchronous orbit
- Fluxes of 400-800 keV electrons at L≈4.5 increase even more quickly and may be a seed population [Li, 1997]
- The acceleration mechanism is unknown but may be wave-particle interactions
- After injection the fluxes in the heart of the radiation belts decrease slowly and monotonically

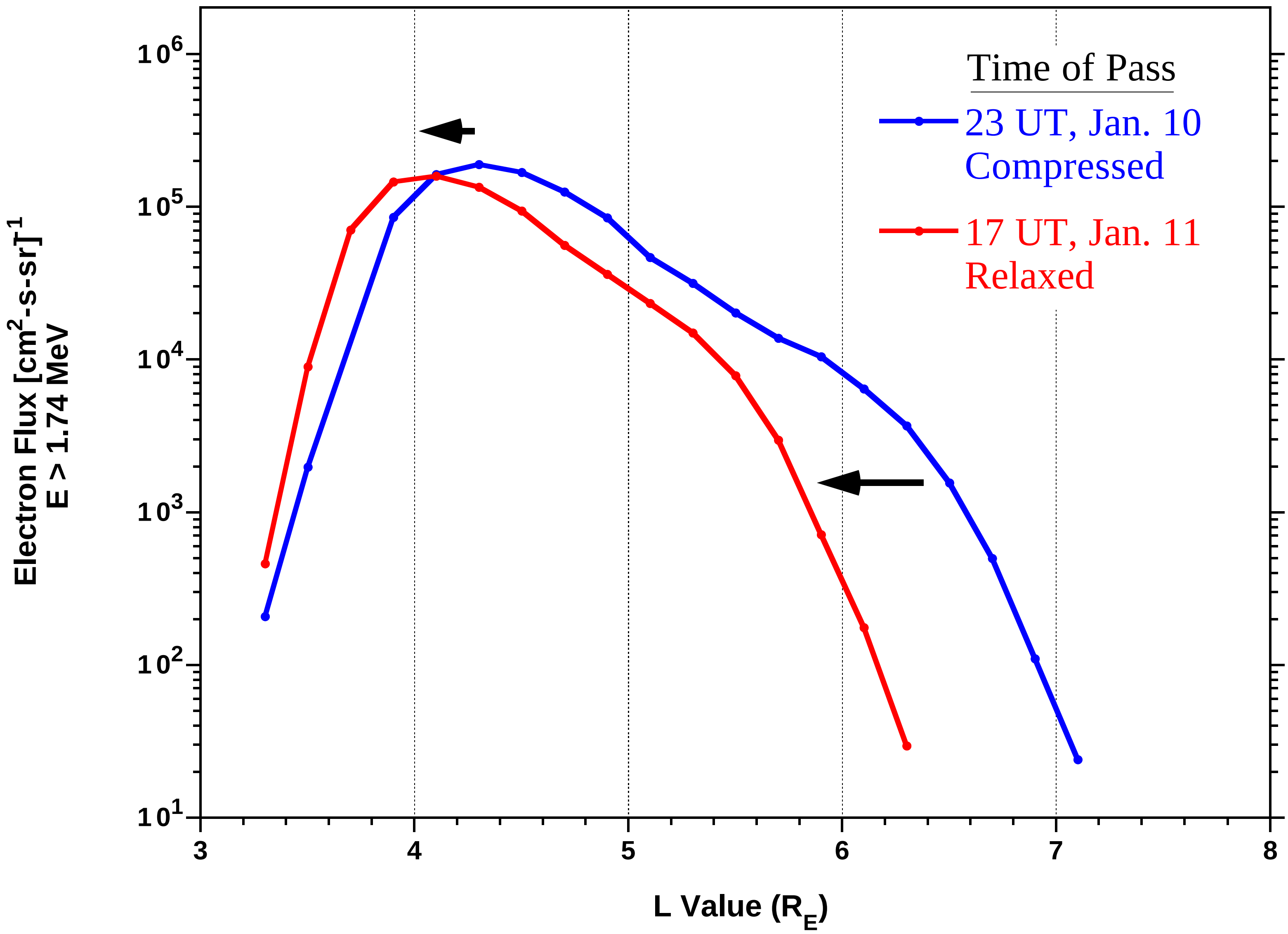
G. D. Reeves, AGU Fall Meeting, Dec. 1997.

First Geosynchronus Electron Peak and Solar Wind Pressure Enhancement



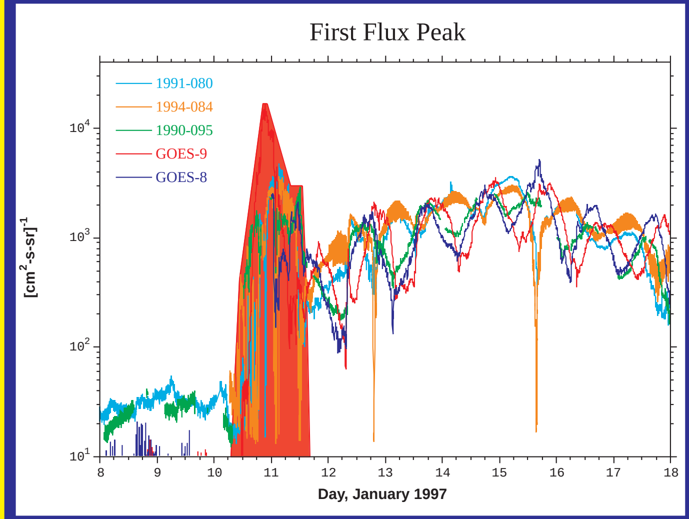
G. D. Reeves, AGU Fall Meeting, Dec. 1997.

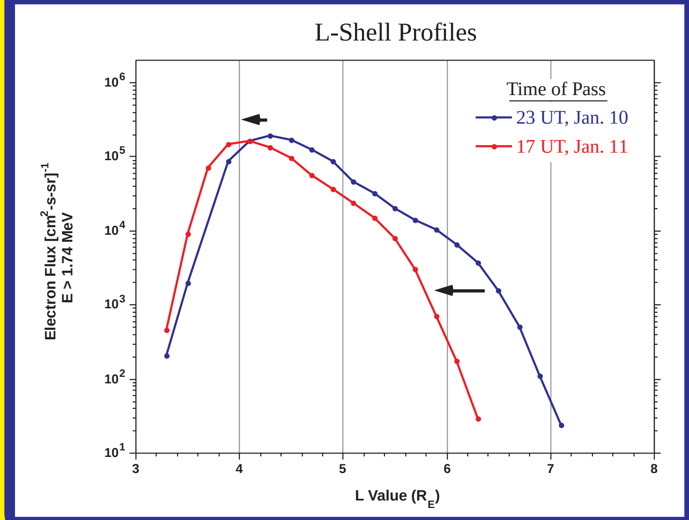
POLAR L-Shell Profiles



G. D. Reeves, AGU Fall Meeting, Dec. 1997.

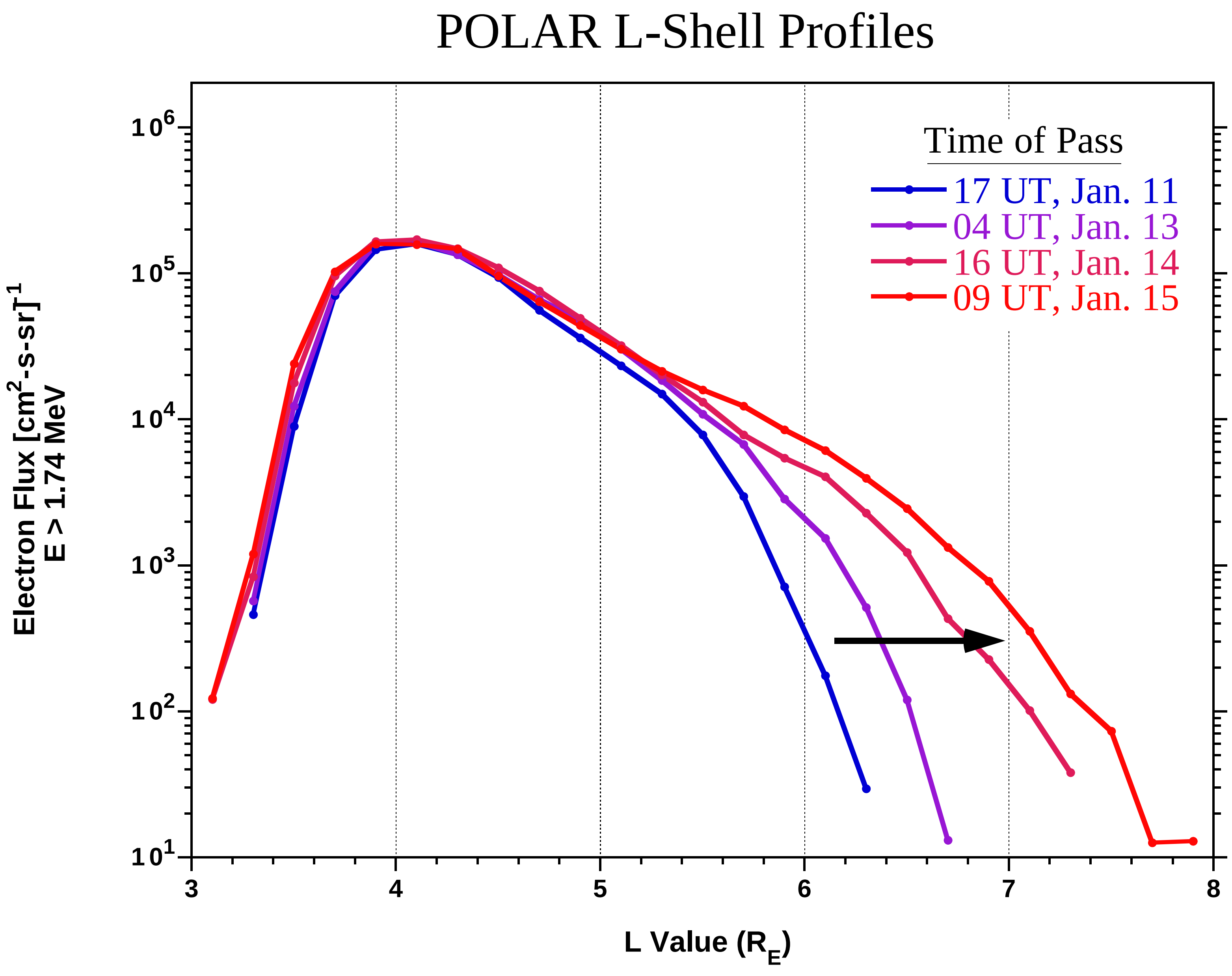
Transport Phase





- The first peak in the >2 MeV electrons at geosynchronous orbit occurred during a magnetospheric compression
- When the magnetosphere relaxes the radiation belts appear to shift earthward
- Compression may have caused an outward shift which increased fluxes at geosynchronous orbit
- Highest fluxes were observed near noon where the field was most compressed
- Not consistent with fully adiabatic transport (μ, J, Φ conserved) but may be consistent with quasi-adiabatic transport (only μ, J conserved)

G. D. Reeves, AGU Fall Meeting, Dec. 1997.



G. D. Reeves, AGU Fall Meeting, Dec. 1997.

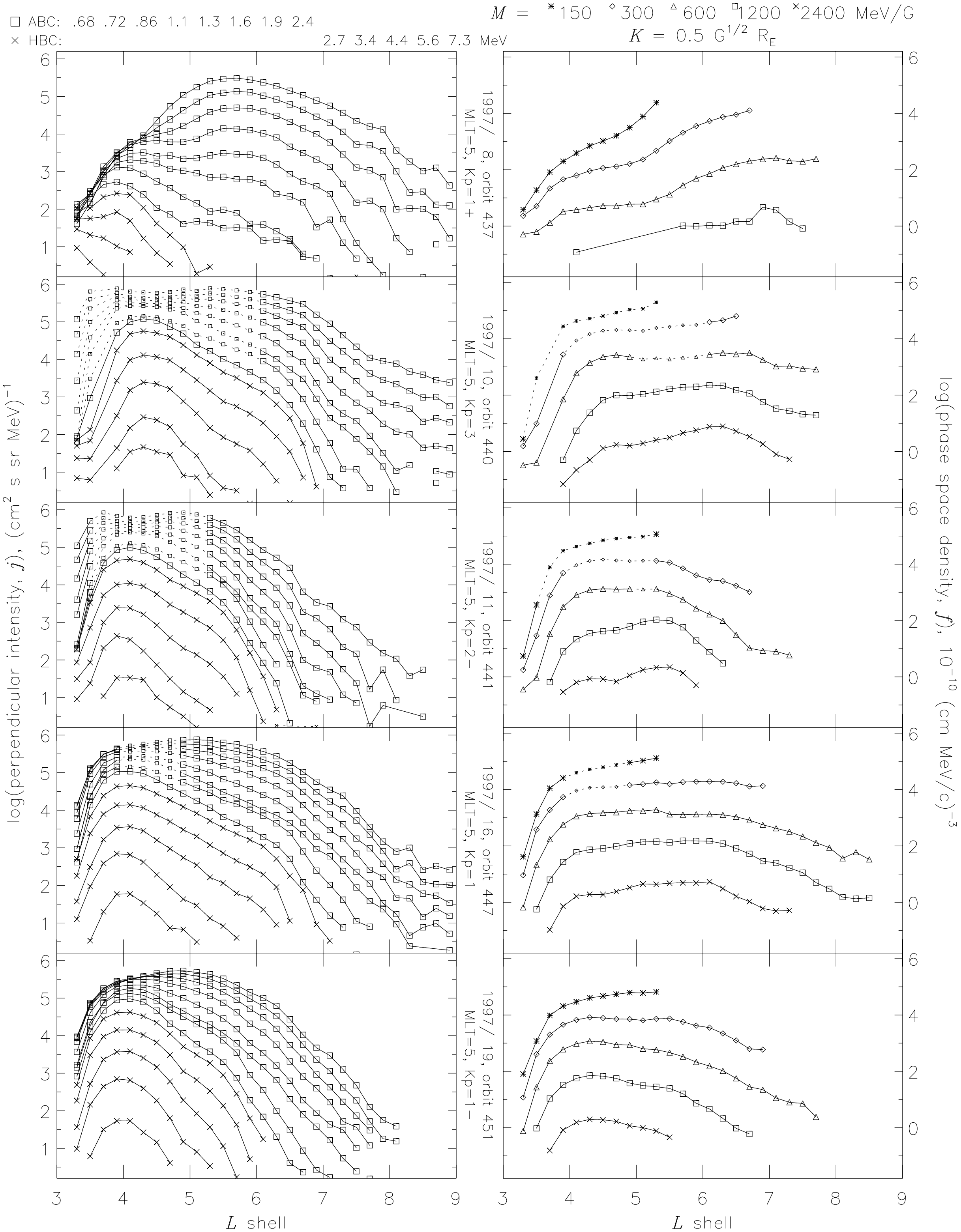
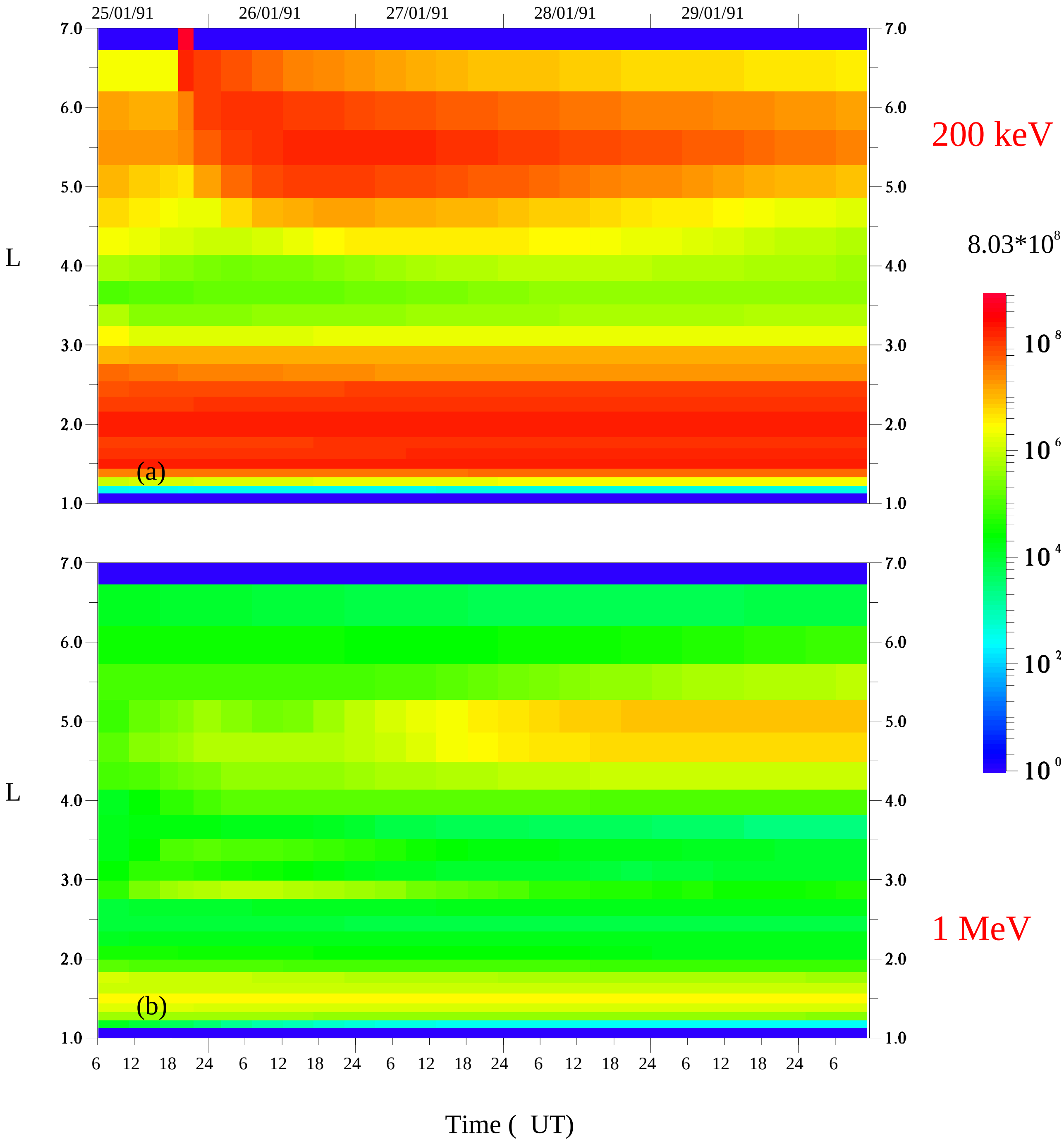


Figure 4. Electron intensity j (left) and phase space density f (right) versus L for selected orbits. The j are at 90° local pitch angle and for the kinetic energies listed at the top. The f are at the listed M and K adiabatic invariant values, with different symbols for each M value. Dashed line segments with smaller symbols represent lower limits due to instrument saturation. Average K_p and magnetic local time (MLT) values for each orbit are shown between the j and f plots.

Selesnick & Blake, GRL 1998.

Salammbo 3D result : January 25, 1991 substorm

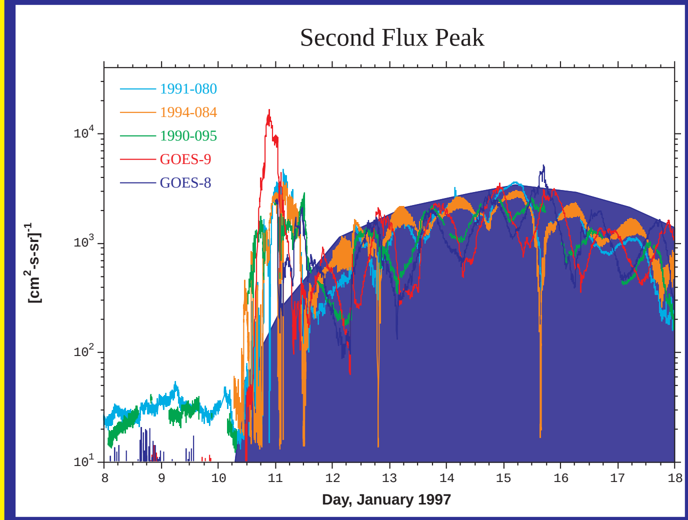
Omnidirectional differential flux (electrons MeV-1 cm-2 s-1)

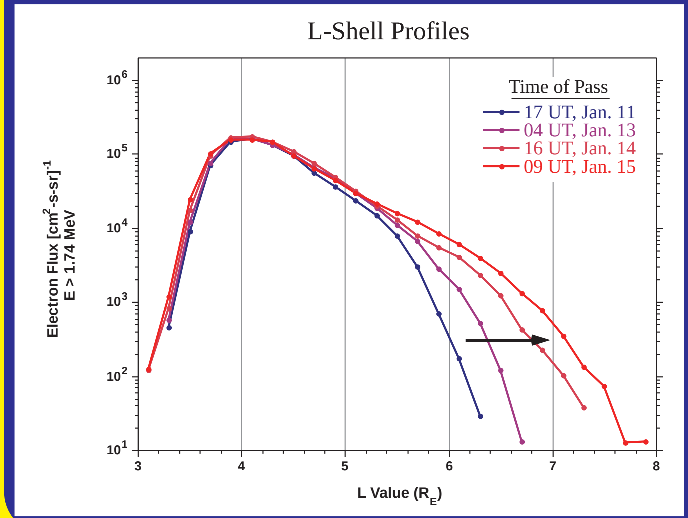


ONERA CERT / DERTS

Bourdarie et al., 1997

Diffusion Phase





- Second peak is much broader and occurs 4 days after storm onset
- A 2-3 day delay was thought to be a general characteristic of the acceleration process (e.g. recirculation)
- It now appears to be a characteristic of only the outer trapping region (e.g. L>5.5)
- L-shell profiles suggest the delayed peak is caused by outward diffusion
- Consistent with SALAMBO model results if the source is at L≈3.5-5.5
- This result has important basic physics and Space Weather implications

G. D. Reeves, AGU Fall Meeting, Dec. 1997.